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**STANDARD INTERFACE FOR
DATA TRANSFER EQUIPMENT**

ENFZ-TM-83-803



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**F-22 SPO PROGRAM
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STANDARD INTERFACE
FOR
DATA TRANSFER EQUIPMENT
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STANDARD INTERFACE
FOR
DATA TRANSFER EQUIPMENT

1.0 SCOPE

This document establishes techniques to be used in the development or modification of airborne data recorders (ADR) (i.e., turbine engine monitoring system recorders, aircraft structural recorders, etc.) and their associated electronic data transfer units -- called data collection units (DCU). It has been developed to ensure compatibility of data transfer devices with a wide variety of flight recorders and should be used to reduce the number of unique DCUs developed to support recording devices. This document describes data communications between DCUs and the associated flight recorders and ground station computers (GSC) or other flight line support equipment.

2.0 APPLICABLE DOCUMENTS

The following documents, of the exact issue shown, form a part of this standard to the extent specified herein. In the event of conflict between the documents referenced herein and the contents of this standard, the contents of this standard shall be the superseding requirement.

GOVERNMENT STANDARDS

MIL-STD-704D	<u>Aircraft Electrical Power Characteristics</u>
MIL-STD-810C	<u>Environmental Test Methods</u>
MIL-STD-1560A	<u>Insert Arrangements for MIL-C-38999 and MIL-C-27599</u> <u>Electrical, Circular Connectors</u>

GOVERNMENT SPECIFICATIONS

MIL-C-38999H	<u>Connectors, Electrical...</u>
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INDUSTRY STANDARDS

EIA STANDARD RS-232C	<u>Interface between Data Terminal Equipment</u> <u>and Data Communication Equipment Employing</u> <u>Serial Binary Data Interchange</u>
EIA STANDARD RS-363	<u>Standard for Specifying Signal Quality for</u> <u>Transmitting and Receiving Data Processing</u> <u>Terminal Equipments Using Serial Data</u> <u>Transmission at the Interface with</u> <u>Non-Synchronous Data Communication Equipment</u>
EIA STANDARD RS-422A	<u>Electrical Characteristics of Balanced</u> <u>Voltage Digital Interface Circuits</u>

3.0 REQUIREMENTS

This section defines the requirements for interfacing airborne data recorders, data transfer devices, and ground computers (or other flight line support equipment). It details both the hardware interface (physical and electrical characteristics) and the data communication protocol (software/firmware programmed) necessary for physical and functional compatibility of all the units mentioned above.

3.1 Hardware Interface Requirements

3.1.1 Physical Characteristics

This section details the physical interface characteristics of the DCU, airborne data recorder, and the ground computer. It addresses control devices located on each piece of equipment, as applicable, and displays since these are part of the equipment interface. Control of the flight and ground equipment using switches or displays will be discussed in detail in the following hardware and software requirements sections.

3.1.1.1 Connectors

All connectors applicable to this interface shall comply with the requirements outlined in MIL-C-38999H, Connectors, Electrical, Circular.., with the following additions/revisions to the requirements:

a) All connectors that can be mated/unmated in a Class 1, Division 1 hazardous location, as defined in the National Fire Protection Association (NFPA) National Electrical Code 70-1983, shall be explosionproof with arc suppression. The explosive atmosphere test shall be in accordance with MIL-STD-810C, Method 511, procedure I.

b) The durability of the connector shall be 1000 mate/unmate cycles when tested per paragraph 4.7.7 of MIL-C-38999H.

c) The connector shall be of a scoop-proof design, have a size 15 shell and use the type B recommended panel mounting dimensions per MIL-C-38999H. The connector shall use the standard 19 pin insert arrangement for the corresponding shell size, per MIL-STD-1560A.

3.1.1.2 DCU Controls and Displays

3.1.1.2.1 Display

The DCU shall have an electro-optical display of at least eight characters. The display may be capable of displaying more ASCII encoded characters than the alphanumerics, but the allowable display characters shall be limited to those listed in Table 2.0. The display shall be capable of displaying a line of 20 characters -- if scrolling is employed to achieve the line display, the character scrolling shall be manually controlled. Each logical line of display information shall be ended with an ASCII encoded carriage return (CR). The memory locations associated with the display shall be transparent to the unit sending the data to the DCU.

3.1.1.2.2 Data Transfer Initiation

The DCU shall have means for switching the battery power to the interface on and initiating communications and data transfer.

3.1.1.2.3 BIT Initiation

The DCU shall have a means for initiating DCU built-in-test as required by the DCU specification or statement of work.

3.1.1.2.4 Fault Indication

The DCU shall have an electro-optical display that automatically

indicates whether or not a fault indicator code has been transmitted to the DCU. The indicator shall be activated as soon as data transfer is completed if a fault code has been transmitted. This function shall be transparent to the transmitting unit as discussed in section 3.2.2.1.7, Fault Indication Byte.

3.1.1.3 Cable(s)

One cable shall be used for connecting a DCU to either an airborne data recorder or a ground computer. The cable shall be designed to meet the requirements specified in section 3.1.2.3 for signal quality and in section 3.1.2.2 for data transfer rates.

3.1.1.4 ADR/DCU Power Requirements

The DCU shall be self-powered and capable of supplying +28VDC to ADRs (when aircraft power is unavailable to the ADR) within the tolerances specified in MIL-STD-704D. The DCU shall sense whether or not power is present on the interface connector before switching its battery power to the interface "on". The DCU may use GSC provided power to power itself. The assumed external load to be serviced by the DCU power shall be 2.0 Amperes for a period of at least 1 hour before recharging shall be required. Any ADRs using the standard interface must also be compatible with MIL-STD-704D power and shall have a rated load of no greater than 2.0 Amperes at +28VDC within the tolerances of MIL-STD-704D.

3.1.2 Electrical Characteristics

This section describes the electrical interface requirements for data communication among DCUs, ADRs, and ground computers.

3.1.2.1 EIA Standard Interfaces

This standard describes 2 Electronics Industries Association (EIA) standard interfaces for data communications -- RS-232C and RS-422A. The airborne data recorders and ground computers shall communicate with the DCU using either interface. The DCU shall incorporate both an RS-232C half-duplex and an RS-422A dual-simplex interface. Details of the interfaces and DCU selection of the active interface are discussed in the following subparagraphs.

3.1.2.1.1 RS-232C Interface

Reference EIA Standard RS-232C. Related cross-reference standards are:

- a) CCITT V.24
- b) CCITT V.28
- c) ISO 2110

Only the "primary data" and "ground" circuits (as defined in the standard) shall be implemented. Control and timing shall be implemented in software as described in Section 3.2, Software and Protocol Interface Requirements.

3.1.2.1.2 RS-422A Interface

Reference EIA Standard RS-422. Related cross-reference standards are:

- a) CCITT V.11 (X.27)
- b) FED-STD-1020

The RS-422 shall be implemented as described in the EIA Standard except for the required circuit driving capability. The implemented interface shall be capable of driving at least two (2) RS-422A receiver circuits. The RS-422A interface shall be capable of satisfactory operation at two (2) discrete Baud rates as specified in paragraph 3.1.2.2, Data Rates.

3.1.2.1.3 DCU Polling to Determine Active Interface

The DCU shall initiate communications on both interfaces as specified in paragraph 3.2.3.8 at the low rate, initially. If no response is received on either low rate interface, the DCU then assumes the active interface is the high-rate RS-422. If no response is received on the high-rate RS-422 interface, the DCU shall declare a communications fault. Timeout and start-up control are discussed further in paragraphs 3.2.3.7 and 3.2.3.8, respectively. After identifying the active interface, the DCU shall communicate only on that interface. The "off" states for the RS-232 and RS-422 interfaces shall be "spacing" and logic high, respectively.

3.1.2.2 Data Rates

The data rate for the RS-232C interface shall be 9.6K Baud (on all equipments). The DCU RS-422 interface shall have a high and a low data rate. The nominal low data rate shall be 9.6K Baud, and the nominal high rate shall be 19.2K Baud.

3.1.2.3 Signal Quality

The following subparagraphs outline the signal quality requirements for the data transmission and reception circuits addressed in this document.

3.1.2.3.1 Transmitters

3.1.2.3.1.1 Distortion

In the communications transmitter circuits, the signal provided shall have a synchronous start-stop distortion not greater than 1.0%, and a gross start-stop distortion of not greater than 2.1%, assuming no signal element shall have a duration of less than 97.9% of a unit interval.

3.1.2.3.1.2 Character Interval

Under continuous start-stop operation, the signals provided on the communications interface may have a minimum average character interval shorter than the nominal character interval and an occasional character with a still shorter duration (called the minimum character interval) according to the following definitions (from EIA Standard RS-363):

a) Minimum Average Character Interval - In continuous start-stop operation, the interval between successive start transitions on the transmitted data circuit averaged over 2 consecutive characters shall be no less than the nominal character interval reduced by 3% of a unit interval.

b) Minimum Character Interval - In continuous start-stop operation, the interval between successive start transitions on the

transmitted data circuit shall not be less than the nominal character interval reduced by 5% of a unit interval.

3.1.2.3.2 Receivers

3.1.2.3.2.1 Receiving Margin

In the start-stop communications system, the receiver(s) shall have a synchronous margin of 2.5% and a practical margin of 35%, and shall not be expected to respond to any signal element having a duration of less than 51.5% of a unit interval.

3.1.2.3.2.2 Character Interval

The receivers shall respond to signals that have a minimum average character interval shorter than the nominal character interval and an occasional character having a still shorter duration (called the minimum character interval) according to the following definitions (from EIA Standard RS-363):

a) Minimum Average Character Interval - In continuous start-stop operation, the implemented receiver(s) shall be prepared to respond to successive start transitions on the received data circuit which follow their previous start transitions by a character interval averaged over 2 consecutive characters which is no less than the nominal character interval reduced by 25% of a unit interval.

b) Minimum Character Interval - In continuous start-stop operation when the above average is met, the receiver(s) shall be prepared to respond to a start transition which follows the start transition of the preceding character by an interval no less than the nominal character interval reduced by 48.5% of a unit interval.

3.1.2.3.2.3 Minimum Duration Start Element

In the communication system, when the receiver is in the stop (or waiting) condition, it shall not be required to respond to a character on a spacing signal element with a duration of less than 51.5% of a unit interval.

3.1.3 DCU Connector Pin Assignments

Electrical signals are assigned to the connector pins as follows:

<u>Pin</u>	<u>Signal</u>
A	RESERVED (no connection)
B	RESERVED (no connection)
C	RS-422A Data High (Received Data, relative to DCU)
D	RS-422A Data Low (Received Data, relative to DCU)
E	+28 VDC
F	+28 VDC Return
G	RS-422A Data High (Transmit Data, relative to DCU)
H	RS-422A Data Low (Transmit Data, relative to DCU)
J	Discrete Test Return
*K	Closure to pin J for data transfer (less than 100 ohms)

L	RS-232C Transmitted Data (circuit BA) (relative to DCU)
M	RS-232C Received Data (circuit BB) (relative to DCU)
N	Signal Ground (circuit AB)
**P	Signal Shields
**R	Protective Ground
S	MIL-STD-1553B Data High (optional)
T	MIL-STD-1553B Data Low (optional)
U	RESERVED (no connection)
V	RESERVED (no connection)

*NOTE: Pin K must be connected to Pin J before communications are attempted and must remain connected until communications are complete. This is necessary for data transfer from ADR to DCU only. The pins may be permanently connected within the DCU. ADR circuits shall supply a maximum of 20 milliamperes through the DCU switching circuit.

**NOTE: Protective ground shall double as the power shield and shall be grounded at both ends of the DCU cable. Signal shields shall be grounded at the ADR/GSC mating end of the cable.

3.2 Software/Protocol Requirements

The SIDTE data transfer protocol defines the allowable ASCII character set, control characters, control concepts, and machine states. The control characters recognized by the protocol shall be limited to those defined in Table 1.0. All display characters and control characters shall be transmitted as defined in Tables 1.0 and 2.0.

3.2.1 Character Set

The character set recognized by this protocol shall be limited to those characters listed in the complete set of codes referred to as the American Standard Code for Information Interchange (ASCII), 1968 (Table 3.0). The characters that may be transmitted in fields that are supplied to the display on the DCU shall be limited to those listed in Table 2.0.

3.2.2 Protocol Format

The protocol defined herein is a character oriented protocol. For this application, asynchronous communications shall be implemented.

3.2.2.1 Header Format

After communications have been established, a header message shall be transmitted once for the entire data package. The header shall be used to preface mass data transfer and request special functions. Its format and field identification shall be as shown in Figure 1.0. Individual fields shall be encoded as specified in the following subparagraphs.

3.2.2.1.1 Start of Header (SOH)

See paragraph 3.2.5.1 and Table 1.0.

3.2.2.1.2 ADR Device Identifier

The device identifier field immediately follows the SOH and is followed by delimiter #1 (DC1). It is a variable length field to accommodate varying device serial numbers. The device identifier shall designate the

intended airborne device for data upload and identify the source of downloaded data. This identifier shall also be used for data segregation on the ground station computer. The device identification shall consist of two parts -- a generic identifier and a specific identifier. The first three bytes shall represent the generic identifier to be used when an upload of numerous devices is desired. A contractor selected 3-byte code shall allow upload of data to any device that recognizes this code thus allowing control of data configuration. When upload to one specific unit is desired, the generic identifier shall contain three nulls. The specific identifier shall occupy the remainder of the field and shall contain the exact serial number of the device for which an upload or request is intended, if required by the particular ADR. The generic identifier shall have priority in deciding whether to allow or disallow an upload. This field shall never contain DCU or GSC identifier numbers.

3.2.2.1.3 Block Count Field

The block count field shall contain a 16-bit numerical value to reflect the number of blocks to be transmitted (65,535 blocks of 256 bytes each, maximum). Least significant byte shall be transmitted first. This count will enable the receiving device to predetermine that sufficient storage capacity exists before the text mode is entered for data transfer. The receiving device shall assume 256 bytes will be contained in all blocks for the capacity calculation.

3.2.2.1.4 Aircraft Tail Number

The aircraft tail number shall be fixed 8-byte field. If the tail number is less than 8 alphanumeric characters, it shall be filled with leading nulls. This field shall always be filled with nulls if the aircraft tail number is not available.

3.2.2.1.5 Aircraft Type Identifier

This shall be a variable length field that designates the aircraft type (i.e., T46A, B1B, etc.). The end of this field shall be identified by delimiter #2 (DC2). If aircraft type is unavailable or unknown to the ADR, this field shall be absent.

3.2.2.1.6 Engine Identifiers

Due to varying aircraft configurations, the engine identifier field shall be variable. The field shall follow DC2 and precede delimiter #3 (DC3). Each engine identifier shall be 8 bytes in length with leading nulls if the number is less than 8 alphanumeric characters. If engine numbers are unavailable or not applicable, this field shall be absent.

3.2.2.1.7 Fault Indication Byte

The presence of any ASCII (Table 2.0) byte within the fault code field shall indicate to the DCU that fault codes have been transmitted from the ADR. The GSC shall place an ASCII coded "!" in this field when initializing the DCU with upload or function request data. This "!" is used only by the DCU to recognize that it has been initialized by a GSC. The character shall be removed by the DCU prior to initiation of communications with an ADR.

3.2.2.1.8 Fault Code Display Field

This shall be of variable length. It shall follow the fault indication byte and precede DC4. Any information transmitted in this field shall be available for DCU display and shall also be transmitted in the transparent data field. If no fault codes were logged by the ADR, this field shall be absent.

3.2.2.1.9 Additional Data Field

The additional data field shall be used for different purposes depending upon the equipment connected and direction of data transfer. For data download (i.e. ADR to DCU to GSC) this field shall contain data that needs to be accessed at the flight line or in the absence of a GSC. Any data transmitted within this field (during a download) shall be available for display by the DCU and shall also be transmitted in the transparent text data blocks as required by each application.

The absence of this field during a DCU to ADR header transmission shall convey to the ADR that a data upload (i.e. GSC to DCU to ADR, or DCU to ADR) is commanded.

The presence of this field during a DCU to ADR header transmission shall convey to the ADR that an application unique function is commanded.

The additional data field shall be followed by delimiter # 5 (FS).

3.2.2.1.10 End of Text (ETX)

See paragraph 3.2.5.4 and Table 1.0.

3.2.2.1.11 Block Check Character (BCC)

The BCC is the result of a Longitudinal Redundancy Check (LRC) and shall be appended to the end of the transmission. This calculation shall be bounded by the start of block (SOH/STX) and end of block (ETB/ETX) exclusively. The BCC functions as a message content error detection scheme. An LRC is defined as a parity on columns. Column parity shall be odd. For example, an odd column parity generates the following BCC.

BYTE

10110010

01101001

11011001

BCC=11111101

An "exclusive OR" (XOR) of the current BCC with the next byte will maintain a BCC of even parity. Complementing the final BCC will provide an odd parity BCC. This calculated BCC shall be appended to the transmission or used for comparison with the received BCC. This approach is illustrated below.

Byte 1	11001101
⊕ Byte 2	10011011
	<u>01010110</u>

⊕ Byte 3	01101100
	00111010
Complement	11000101 = BCC

3.2.2.2 Data Transfer Format

After communications have been established and documentary (header) data has been received, the transfer of data shall be accomplished using the data format as shown in Figure 2.0.

3.2.2.2.1 Start of Text (STX)

See paragraph 3.2.5.2 and Table 1.0.

3.2.2.2.2 Data Byte Count

An 8-bit numerical value defining the data block size (256 bytes or less). This technique shall facilitate data transparency and assist detection of transmission errors. Zero shall represent 256. If there is no data to send, the block count (see 3.2.2.1.3) will be equal to zero (0).

3.2.2.2.3 Transparent Data Field

This field shall contain data which is peculiar to the application itself. The interpretation and/or processing of this information shall be a function of the particular device for which it is intended (i.e., acquisition device or ground computer).

3.2.2.2.4 End of Block (ETB)

See paragraph 3.2.5.3 and Table 1.0.

3.2.2.2.5 End of Text (ETX)

See paragraph 3.2.5.4 and Table 1.0.

3.2.2.2.6 Block Check Character (BCC)

See paragraph 3.2.2.1.11.

3.2.3 Protocol Considerations

Protocol implementation considerations are discussed in the following subparagraphs.

3.2.3.1 Framing Control

Framing is defined as the determination of which eight bit groups constitute characters and what groups of characters constitute messages. Each 8-bit data byte transmitted shall be preceded by 1 start bit and followed by an odd parity bit and 1 stop bit. The byte shall be transmitted least significant bit first. The transparent data field (see 3.2.2.2.3) encoding shall be defined by the contractor for each peculiar ADR application. The following information shall be transmitted ASCII encoded:

- All control characters (per Table 1.0)
- ADR identifier number
- Aircraft tail number
- Aircraft type
- Engine identifier(s)
- Fault and additional data display information

The following information shall be transmitted non-ASCII encoded:

- a) Block count (two bytes)
- b) Block check character
- c) Data byte count

3.2.3.2 Error Control

Error detection shall consist of hardware detected parity error on all bytes, erroneous LRC value, and transmission related problems (i.e., loss of communications, etc.).

3.2.3.2.1 Byte Parity Error

A byte parity error detected during the reception of a header or text block shall result in a receiver request for retransmission (NAK) after the block transmission has terminated. Such an error detected during the reception of single control characters (for handshaking) shall generate a negative acknowledgement (NAK) resulting in the retransmission of the control character. Five (5) retransmission attempts shall be made before declaring a communications fault.

3.2.3.2.2 LRC Error

An erroneous LRC value in the BCC shall generate a negative acknowledgement (NAK) response by the receiver. The transmitter shall make five (5) attempts to retransmit the same block before declaring a communications fault.

3.2.3.3 Sequence Control

Since communications used in this interface are half-duplex, message numbering is not required. A positive acknowledgement control character shall be sent in response to correctly received control characters and data blocks as illustrated in the functional flowcharts. The affirmative acknowledgement control character shall be transmitted as the ASCII code for ACK. The reverse interrupt control character is an affirmative acknowledgement transmitted as the ASCII code for RVI. The ACK and RVI characters maintain transmission sequence and establish the line direction.

3.2.3.4 Transparency

Transparency of application unique data is imperative to avoid interpretation of data as control characters. Transparency shall be achieved by the data byte count technique.

3.2.3.5 Line Control

Communication initiation shall be as defined in 3.2.3.8. Determination as to which device has control of the line at any particular instant is a function of the control character handshaking process and DCU initialized state. (Reference functional flowcharts.)

3.2.3.6 Special Cases

3.2.3.6.1 No Data to Send

If an ADR has no data to send to the DCU, it simply responds to the DCU's ENQ with the normal RVI to turn the communication line around and

sends a header with a zero block count. If a DCU is empty it responds to a GSC acknowledgement with a header containing a zero block count and a fault code reflecting no data to send.

3.2.3.7 Timeout Control

If communications are lost for a period of 500 milliseconds, at any time, a timeout condition shall be declared; communication lines shall be returned to logic high or spacing conditions and startup shall be attempted as described in paragraphs 3.1.2.1.3 and 3.2.3.8 before declaring a communications fault.

3.2.3.8 Startup Control

The DCU shall initiate communications by delaying at least 1 second after application of power to the interface, followed by repeated transmission of the ENQ control character for 2 seconds at 50 millisecond intervals, or until an affirmative acknowledgement is received by the DCU. The equipment receiving the ENQ shall respond with an affirmative acknowledgement control character depending on the desired line direction and function.

3.2.4 Communications Between Devices

The flowcharts referenced by the following paragraphs are intended to depict information flow, state transitions, and line control in a normal mode of operation. These are functional flowcharts and are not intended to depict the software structure to achieve implementation.

3.2.4.1 ADR/DCU Communications

The communications between these devices shall be limited to three major functions. They are: 1) downloading of ADR accumulated data, 2) uploading of data to the ADR, and 3) function requests.

3.2.4.1.1 ADR to DCU Download

This function is estimated to constitute the major operational useage of this interface. Once the physical connection has been made and communications initiated the data transfer shall progress as illustrated in figures A1.0, A1.1 and D1.0. These figures are referenced in the following discussion.

3.2.4.1.1.1 Communications Setup

Once the ADR interface has been enabled it awaits the reception of an ENQ control character. If the ADR needs to perform BIT or other internal housekeeping prior to initiating communications it enters a wait handshaking process denoted by A1.0 (1). When ready to proceed the recorder responds with a reverse interrupt control character (RVI) to attempt an automatic download.

3.2.4.1.1.2 DCU Determination

Once communications have been established and the DCU has received the expected RVI it shall respond according to its initialized state. The DCU shall be initialized by either the GSC or its own keyboard to perform a specific function.

3.2.4.1.1.3 Data Transfer

The DCU responds with an ACK to allow automatic download if it has not been initialized to perform a different task. When the ADR recognizes this ACK, A1.0 (2), it enters the download mode. The header is then transmitted and the response is received from the DCU. This response could be one of 4 acknowledgements. A NAK would request retransmission, a WACK would hold the communications and either an RVI or ACK would transition control from the transmit header mode back to the download mode. If the response is an RVI at this point the DCU has aborted transfer. The ADR acknowledges (ACK) this and awaits the reestablishment of communications. If the DCU response was an ACK the ADR enters a transmit text mode. Once all data has been transferred the DCU acknowledges the last block with an RVI, thus returning control to the DCU. The ADR then acknowledges the request and awaits reestablishment of communications.

3.2.4.1.2 DCU to ADR Upload

DCU to ADR upload procedures are depicted in Figures A1.0, D1.0, and D1.1.

3.2.4.1.3 Application Unique Function Requests

Reference figures A1.0, A1.3, DA1.0, and DA1.3.

3.2.4.2 DCU to GSC Communications

The functions performed on this interface shall be limited to: 1) acceptance of ADR accumulated data via the DCU, 2) initialization of the DCU to perform an ADR upload, and 3) initialization of the DCU to perform a function request of the ADR.

3.2.4.2.1 DCU to GSC Download

Reference Figures G1.0 and DG1.0.

3.2.4.2.2 GSC to DCU Upload

Reference Figures G1.0 and DG1.1.

3.2.4.2.3 Function Request Initialization

Reference Figures G1.0 and DG1.1.

3.2.4.3 ADR - Subsystem Communications

To be supplied (TBS) when applicable

3.2.5 Control Character Definitions

The control characters are defined in the paragraphs that follow. All control characters are transmitted ASCII encoded as defined in Table 1.0.

3.2.5.1 Start of Header (SOH)

As the name implies, this control character identifies the data that follows as header information.

3.2.5.2 Start of Text (STX)

This character identifies the beginning of text data.

3.2.5.3 End of Transmission Block (ETB)

ETB identifies the end of a transmitted block which began with STX and indicates that the block check character (BCC) follows.

3.2.5.4 End of Text (ETX)

ETX marks the end of a block which started with either SOH or STX. Its function is the same as ETB except that it indicates no more data blocks to send in the case of STX.

3.2.5.5 Negative Acknowledgement (NAK)

This is the response to the transmitting device that the last block or control character was received in error and shall be retransmitted.

3.2.5.6 Enquiry (ENQ)

ENQ is used to establish communications.

3.2.5.7 Affirmative Acknowledgement (ACK)

This control character verifies to the sender that the previous block was received without errors, or is used (when applicable) as an affirmative acknowledgement of a correctly received control character.

3.2.5.8 Wait Before Transmit Positive Acknowledgement (WACK)

A WACK response from the receiving device is an affirmative acknowledgement of a block, and indicates the receiver is not ready to receive the next block. The transmitting device sends ACK and the receiver responds with WACK at least once every 450 milliseconds (to prevent a time-out condition as described in paragraph 3.2.3.7) until ready to receive the next block. When the receiver is ready, it responds with an ACK.

3.2.5.9 Reverse Interrupt (RVI)

An RVI is an affirmative acknowledgement. It requests the transmitting device to assume the role of receiver and thus turn the communication line around.

3.2.5.10 Temporary Text Delay (TTD)

This control character is sent by the transmitting device when it is not ready but wants to retain the line. The receiver responds with ACK to each TTD sent until the transmitter is ready. The transmitter shall send a TTD control character at least once every 450 milliseconds to retain the line.

3.2.5.11 Data Delimiters (DC1, DC2, DC3, DC4, FS)

The codes for the 5 data delimiters are defined in Table 1.0.

CONTROL CHARACTER CODE ASSIGNMENTS

<u>CONTROL CHARACTER</u>	<u>OCTAL</u>	<u>HEXIDECIMAL</u>	<u>DECIMAL</u>
SOH	001	01	1
STX	002	02	2
ETX	003	03	3
ENQ	005	05	5
ACK	006	06	6
DC1	021	11	17
DC2	022	12	18
DC3	023	13	19
DC4	024	14	20
NAK	025	15	21
ETB	027	17	23
FS	034	1C	28
WACK	035	1D	29
RVI	036	1E	30
TTD	037	1F	31

TABLE 1.0

ASCII DISPLAY CHARACTERS

<u>CHARACTER</u>	<u>OCTAL</u>	<u>HEXIDECIMAL</u>	<u>DECIMAL</u>
null	000	00	0
CR	015	0C	12
space	040	20	32
"	042	22	34
\$	044	24	36
%	045	25	37
&	046	26	38
'	047	27	39
(050	28	40
)	051	29	41
*	052	2A	42
+	053	2B	43
,	054	2C	44
-	055	2D	45
.	056	2E	46
/	057	2F	47
0	060	30	48
1	061	31	49
2	062	32	50
3	063	33	51
4	064	34	52
5	065	35	53
6	066	36	54
7	067	37	55
8	070	38	56
9	071	39	57
<	074	3C	60
=	075	3D	61
>	076	3E	62
?	077	3F	63
@	100	40	64
A	101	41	65
B	102	42	66
C	103	43	67
D	104	44	68
E	105	45	69
F	106	46	70
G	107	47	71
H	110	48	72
I	111	49	73
J	112	4A	74
K	113	4B	75
L	114	4C	76
M	115	4D	77
N	116	4E	78
O	117	4F	79

P	120	50	80
Q	121	51	81
R	122	52	82
S	123	53	83
T	124	54	84
U	125	55	85
V	126	56	86
W	127	57	87
X	130	58	88
Y	131	59	89
Z	132	5A	90

TABLE 2.0

ASCII CODES (1968)

<u>DEFINITION</u>	<u>OCTAL</u>	<u>HEXIDECIMAL</u>	<u>DECIMAL</u>
NUL	000	00	0
SOH	001	01	1
STX	002	02	2
ETX	003	03	3
EOT	004	04	4
ENQ	005	05	5
ACK	006	06	6
BEL	007	07	7
BS	010	08	8
HT	011	09	9
LF	012	0A	10
VT	013	0B	11
FF	014	0C	12
CR	015	0D	13
SO	016	0E	14
SI	017	0F	15
DLE	020	10	16
DC1	021	11	17
DC2	022	12	18
DC3	023	13	19
DC4	024	14	20
NAK	025	15	21
SYN	026	16	22
ETB	027	17	23
CAN	030	18	24
EM	031	19	25
SUB	032	1A	26
ESC	033	1B	27
FS	034	1C	28
GS	035	1D	29
RS	036	1E	30
US	037	1F	31
SP	040	20	32
!	041	21	33
"	042	22	34
#	043	23	35
\$	044	24	36
%	045	25	37
&	046	26	38
'	047	27	39
(050	28	40
)	051	29	41
*	052	2A	42
+	053	2B	43
,	054	2C	44
-	055	2D	45
.	056	2E	46
/	057	2F	47

0	060	30	48
1	061	31	49
2	062	32	50
3	063	33	51
4	064	34	52
5	065	35	53
6	066	36	54
7	067	37	55
8	070	38	56
9	071	39	57
:	072	3A	58
;	073	3B	59
<	074	3C	60
=	075	3D	61
>	076	3E	62
?	077	3F	63
@	100	40	64
A	101	41	65
B	102	42	66
C	103	43	67
D	104	44	68
E	105	45	69
F	106	46	70
G	107	47	71
H	110	48	72
I	111	49	73
J	112	4A	74
K	113	4B	75
L	114	4C	76
M	115	4D	77
N	116	4E	78
O	117	4F	79
P	120	50	80
Q	121	51	81
R	122	52	82
S	123	53	83
T	124	54	84
U	125	55	85
V	126	56	86
W	127	57	87
X	130	58	88
Y	131	59	89
Z	132	5A	90
[133	5B	91
\	134	5C	92
]	135	5D	93
^	136	5E	94
_	137	5F	95
/	140	60	96
a	141	61	97
b	142	62	98
c	143	63	99

d	144	64	100
e	145	65	101
f	146	66	102
g	147	67	103
h	150	68	104
i	151	69	105
j	152	6A	106
k	153	6B	107
l	154	6C	108
m	155	6D	109
n	156	6E	110
o	157	6F	111
p	160	70	112
q	161	71	113
r	162	72	114
s	163	73	115
t	164	74	116
u	165	75	117
v	166	76	118
w	167	77	119
x	170	78	120
y	171	79	121
z	172	7A	122
{	173	7B	123
	174	7C	124
}	175	7D	125
~	176	7E	126
DEL	177	7F	127

TABLE 3.0

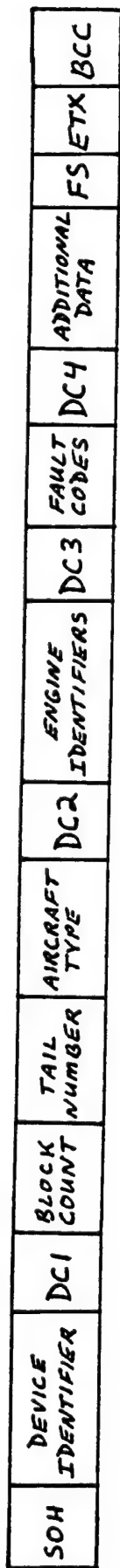


FIGURE 1.0, "HEADER BLOCK FORMAT"

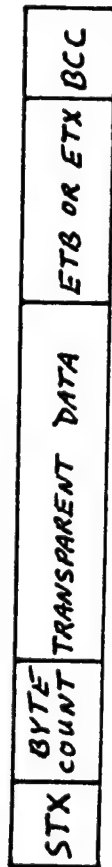


FIGURE 2.0, "TEXT BLOCK FORMAT"

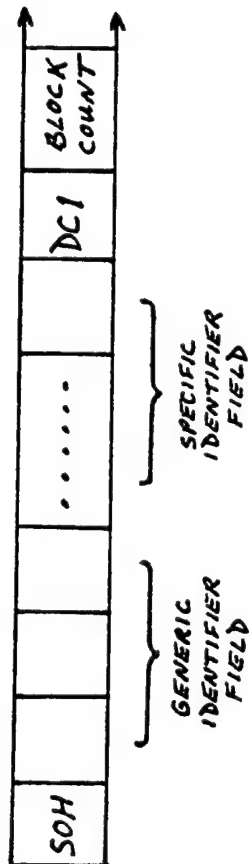


FIGURE 3.0, "DEVICE IDENTIFIER FIELD"

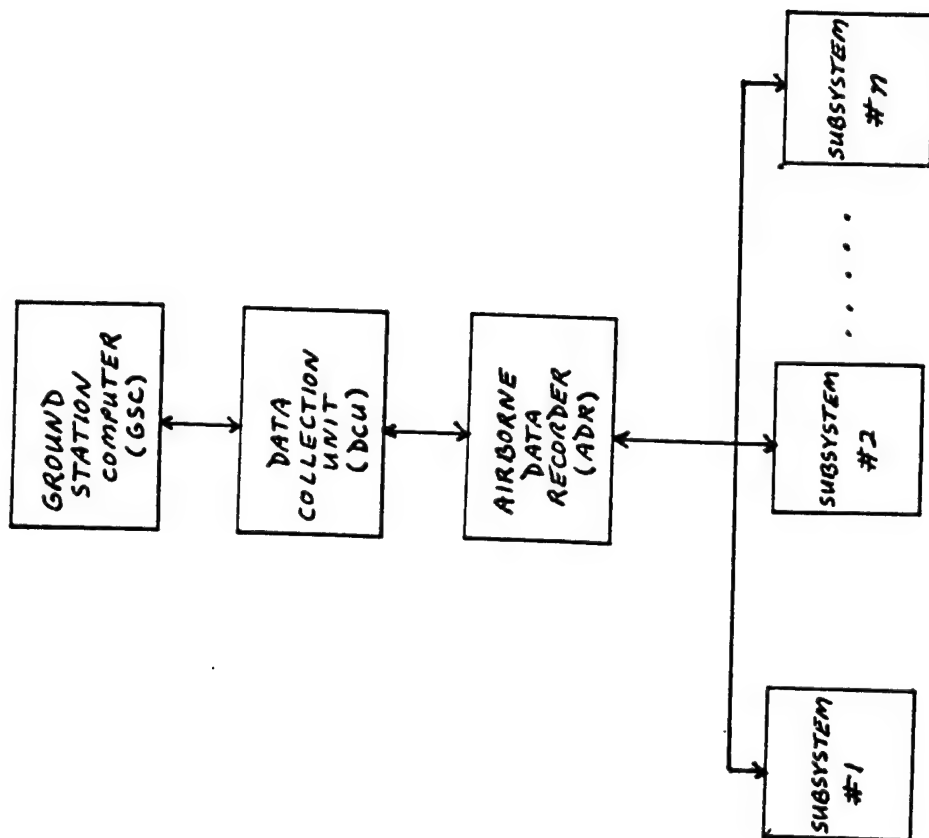


FIGURE 4.0, "EQUIPMENT INTERFACES"

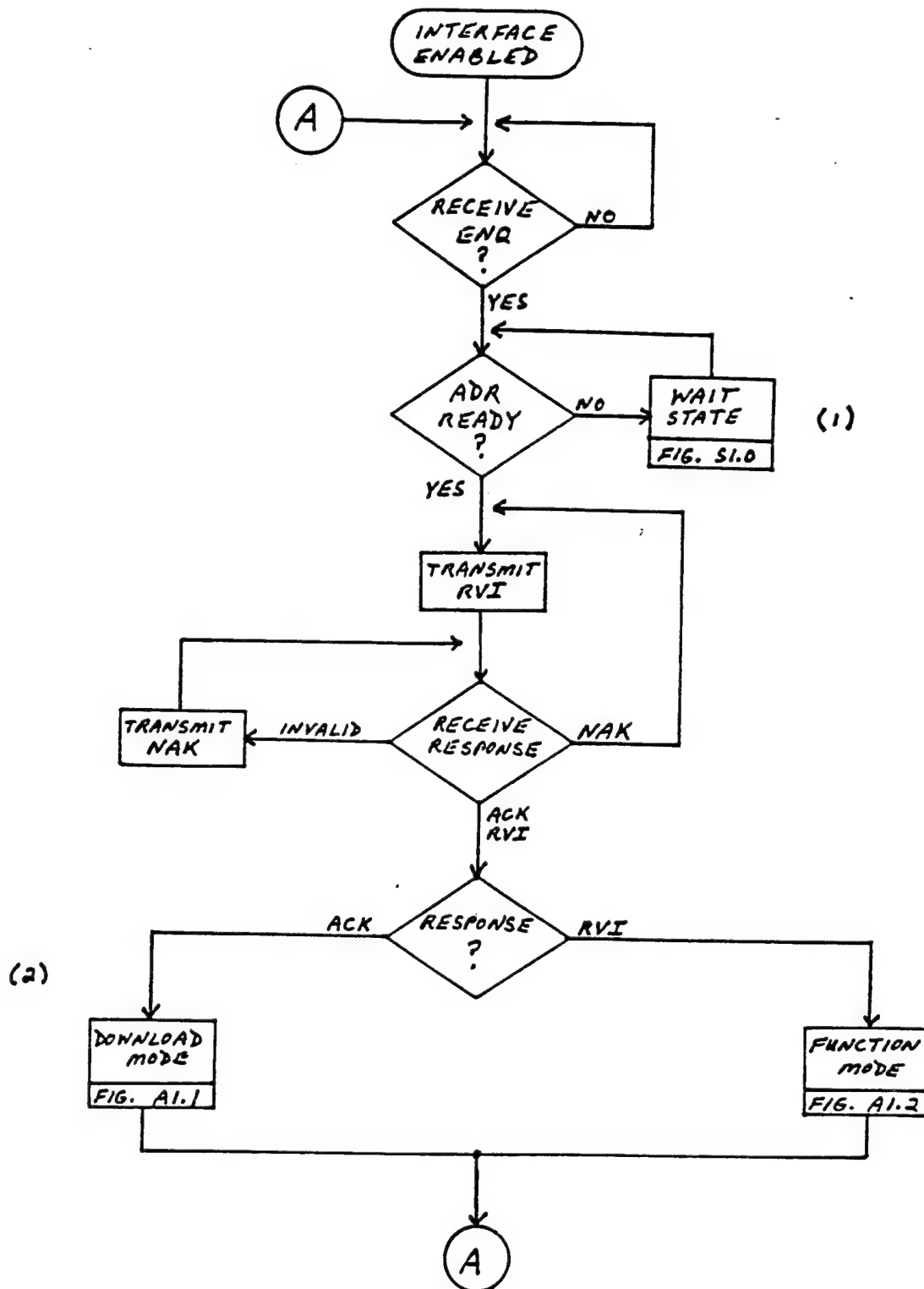


FIGURE A1.0, "ADR TO DCU COMMUNICATIONS"

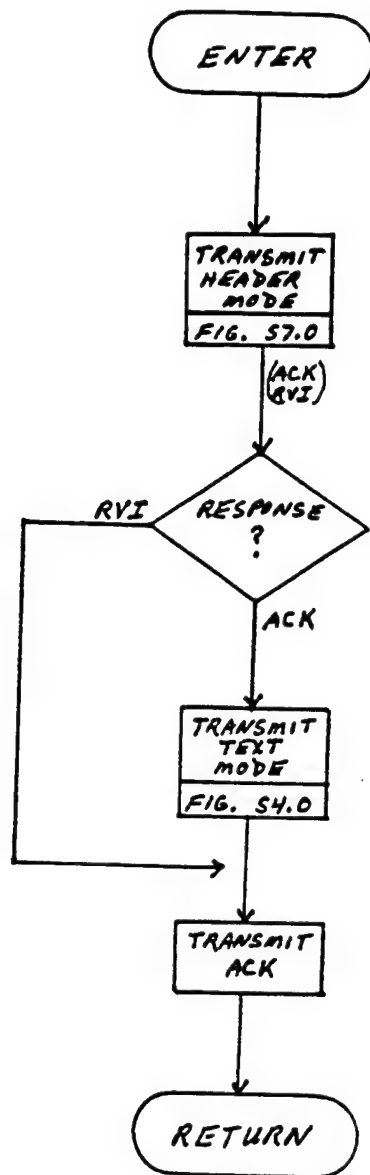


FIGURE A1.1, "ADR TO DCU DOWNLOAD MODE"

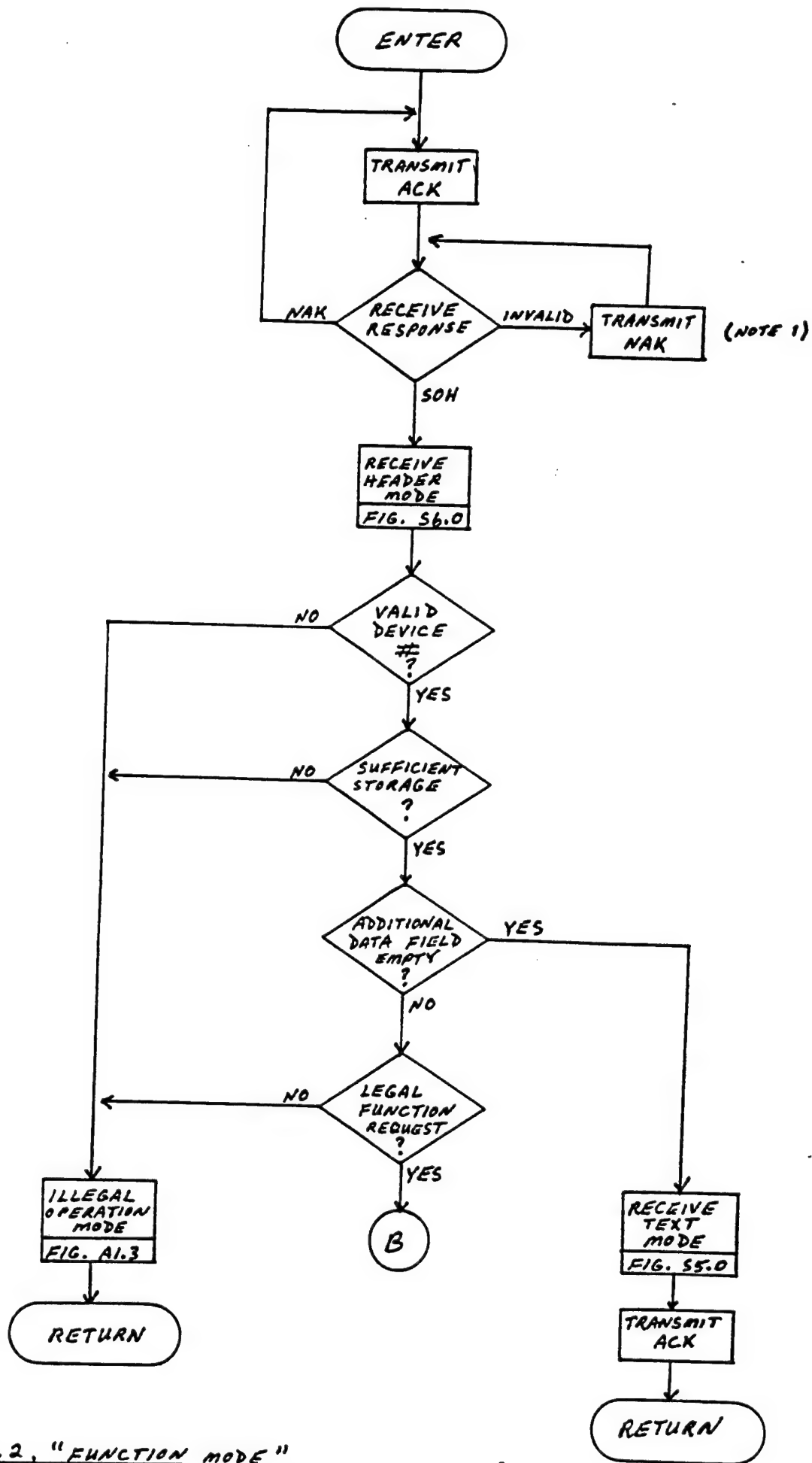


FIGURE A1.2, "FUNCTION MODE"

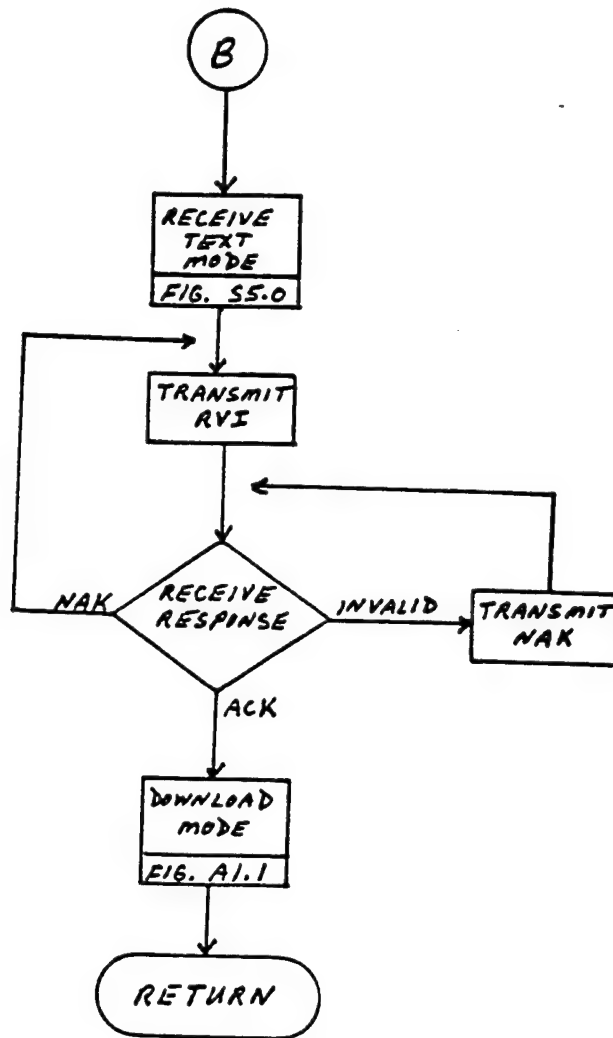


FIGURE A1.2, "FUNCTION MODE" (CONTINUED)

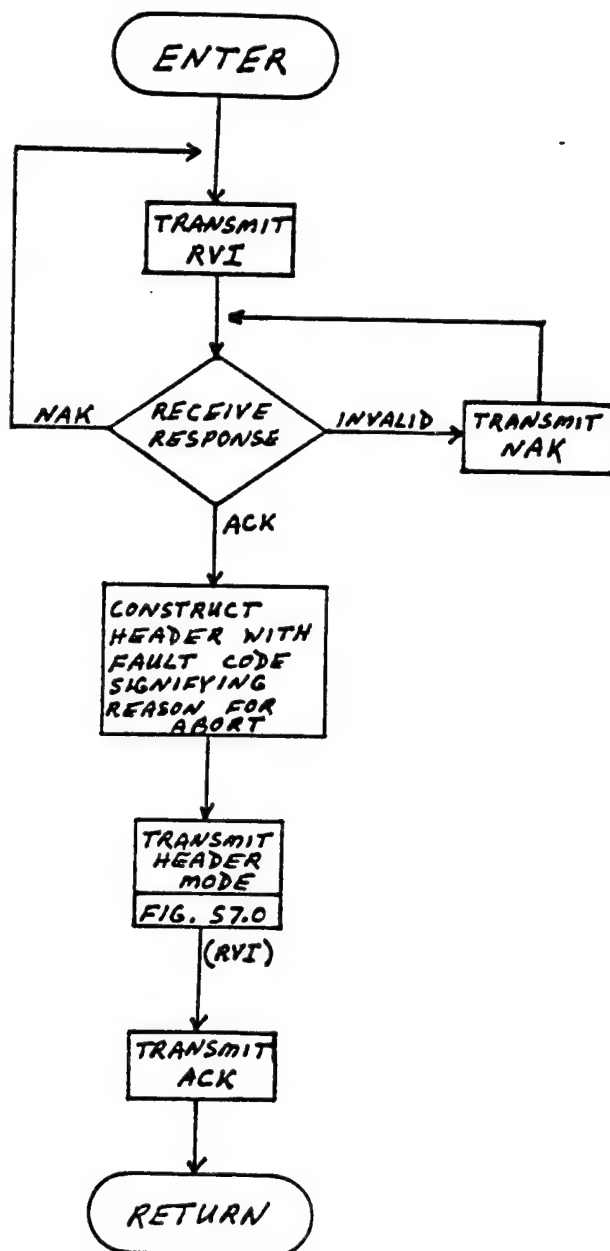


FIGURE A1.3, "ILLEGAL OPERATION MODE"

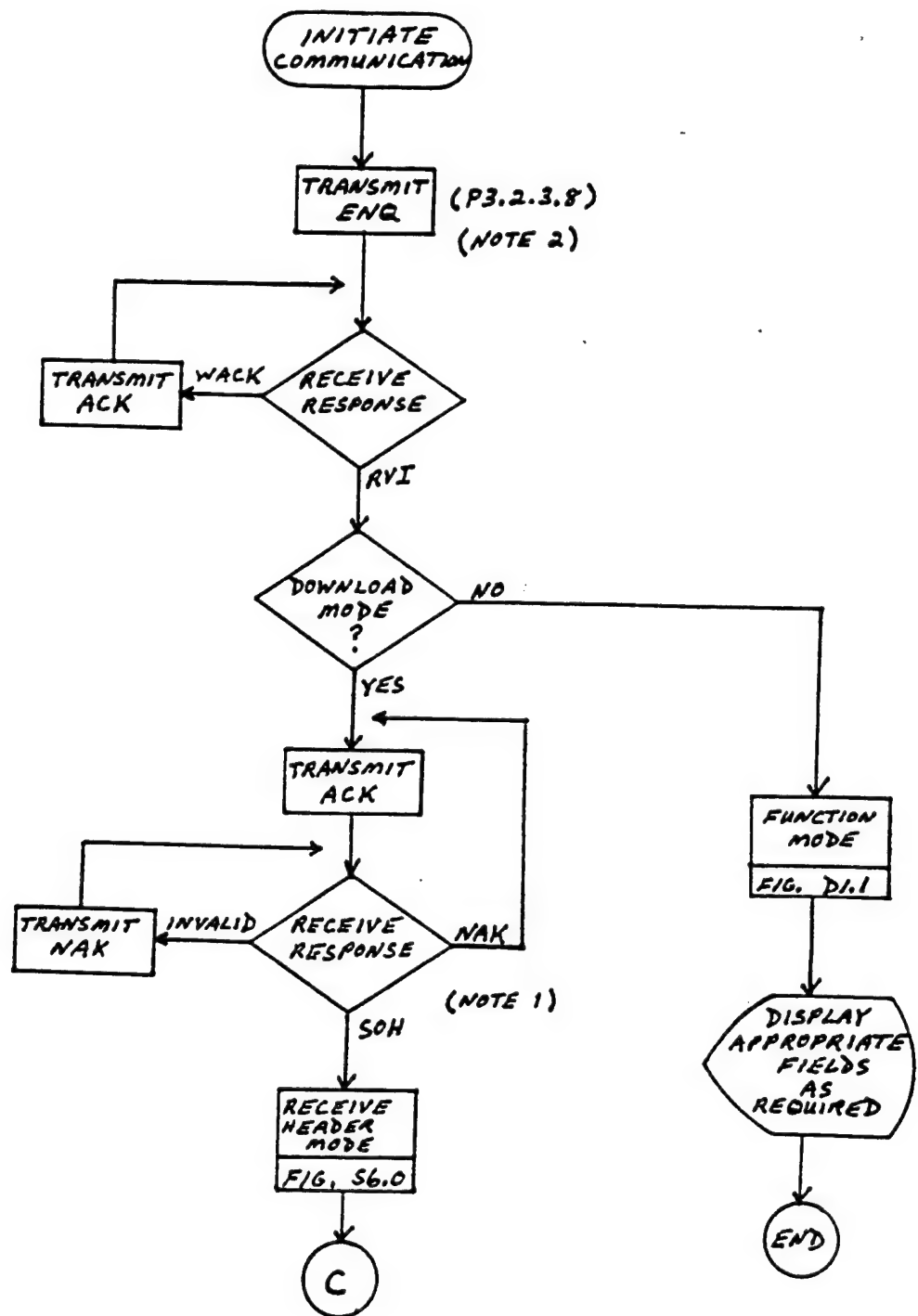


FIGURE D1.0, "DCU TO ADR COMMUNICATIONS"

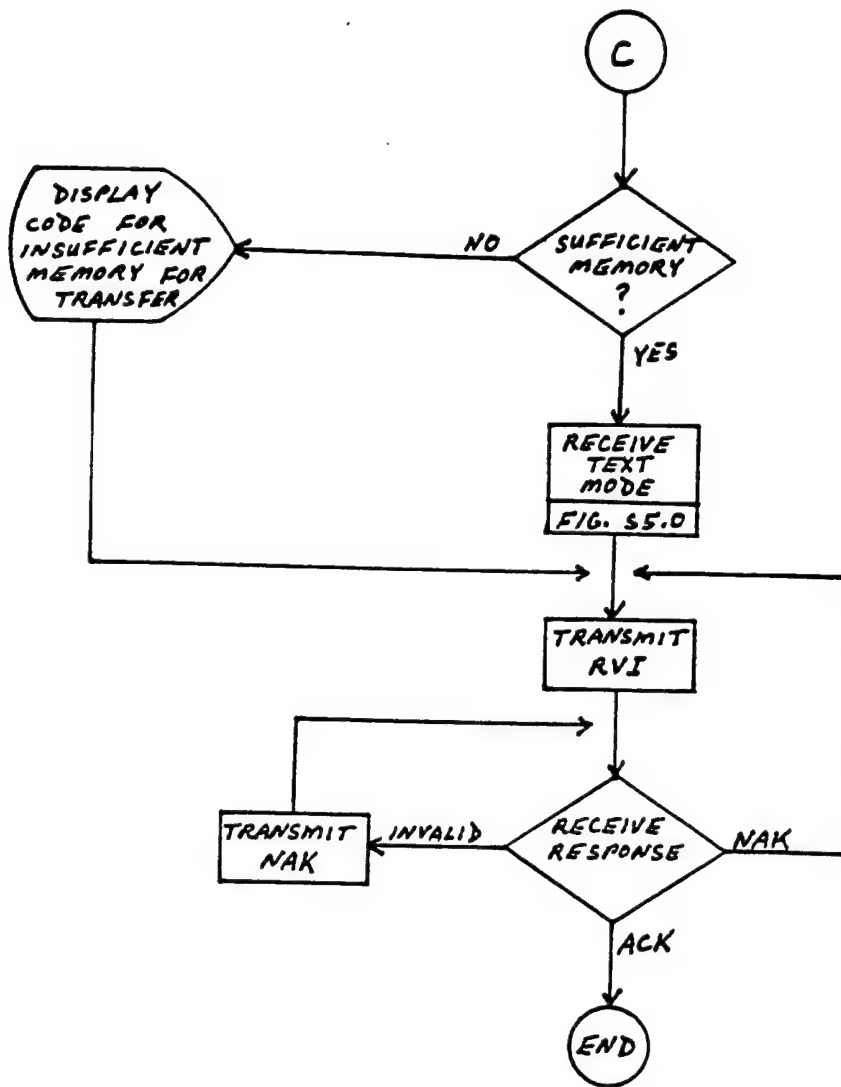


FIGURE D1.0, "DCU TO ADR COMMUNICATIONS" (CONTINUED)

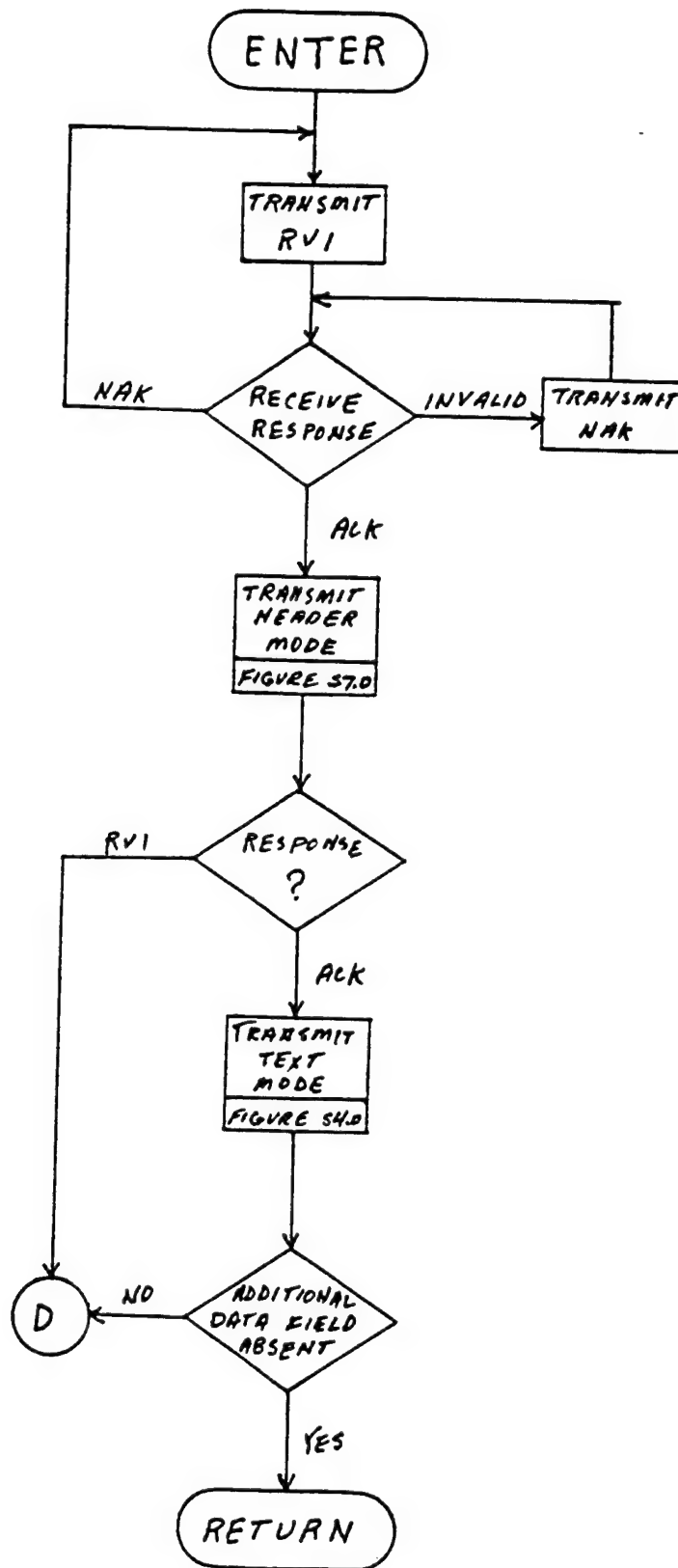


FIGURE D1.1 "SPECIAL FUNCTION MODE"

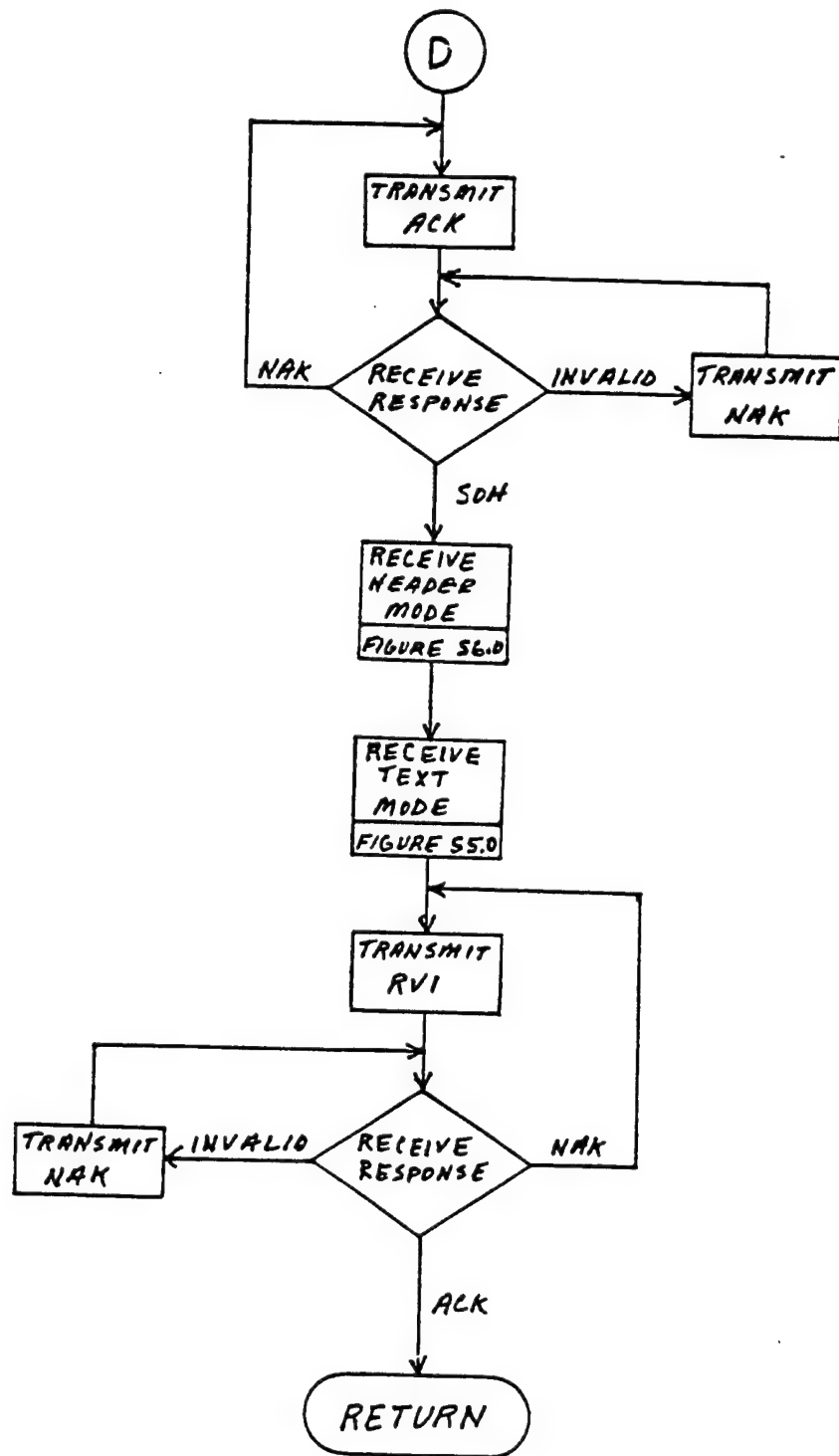


FIGURE D1.1, (CONTINUED)

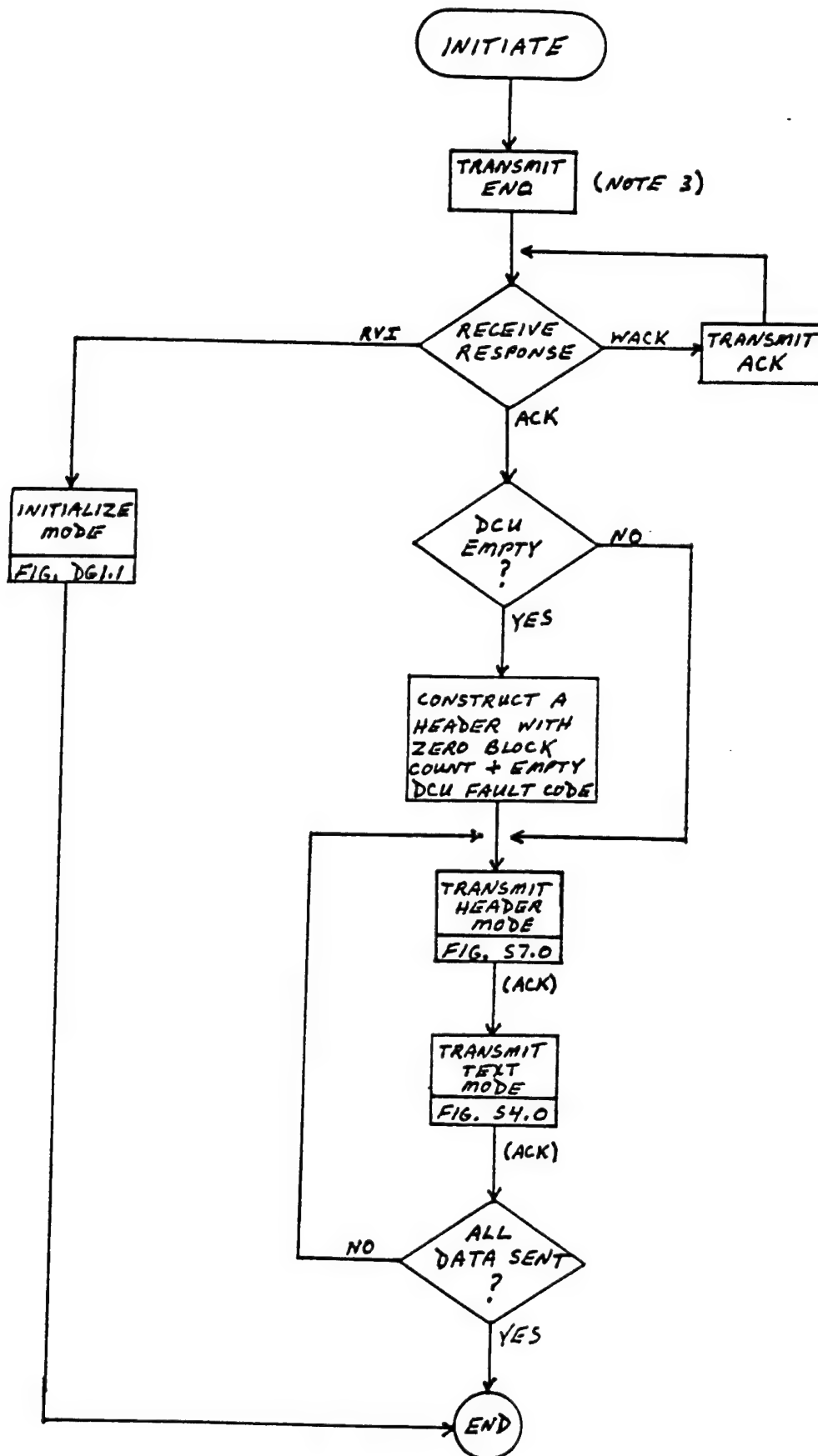


FIGURE DG1.0, "DCU TO GSC COMMUNICATIONS"

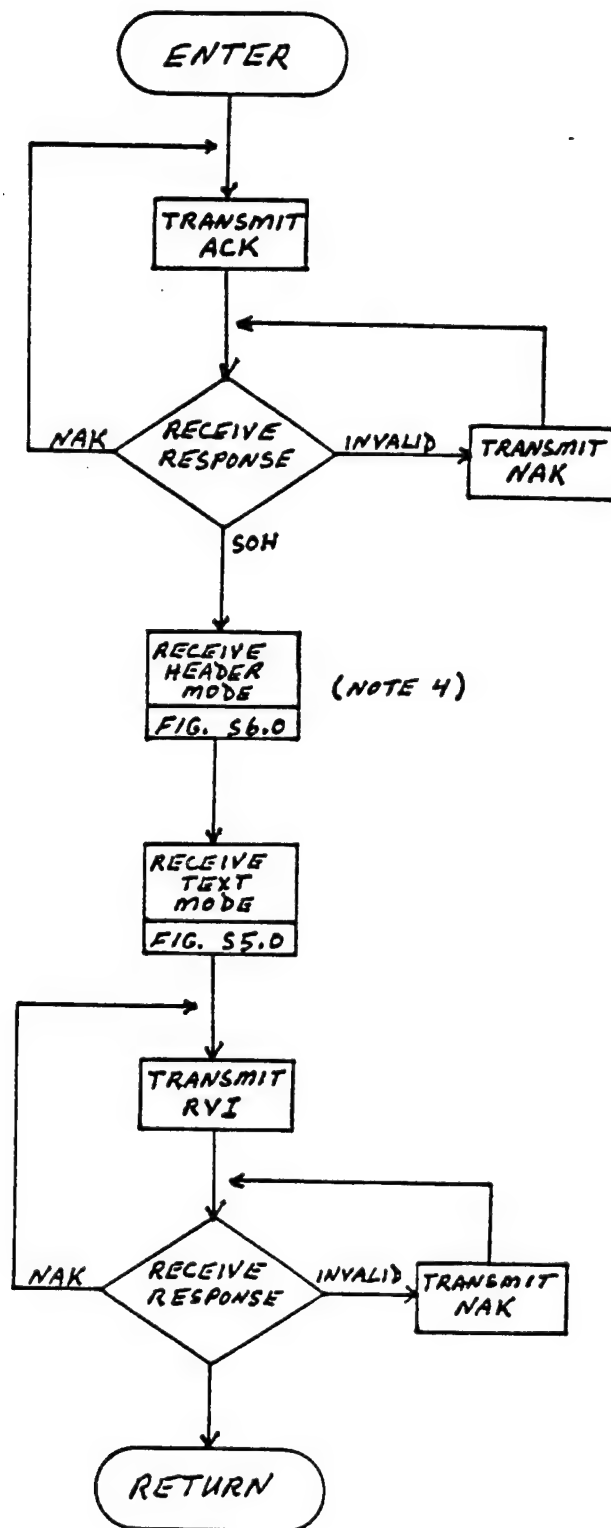


FIGURE D61.1, "DCU TO GSC INITIALIZATION MODE"

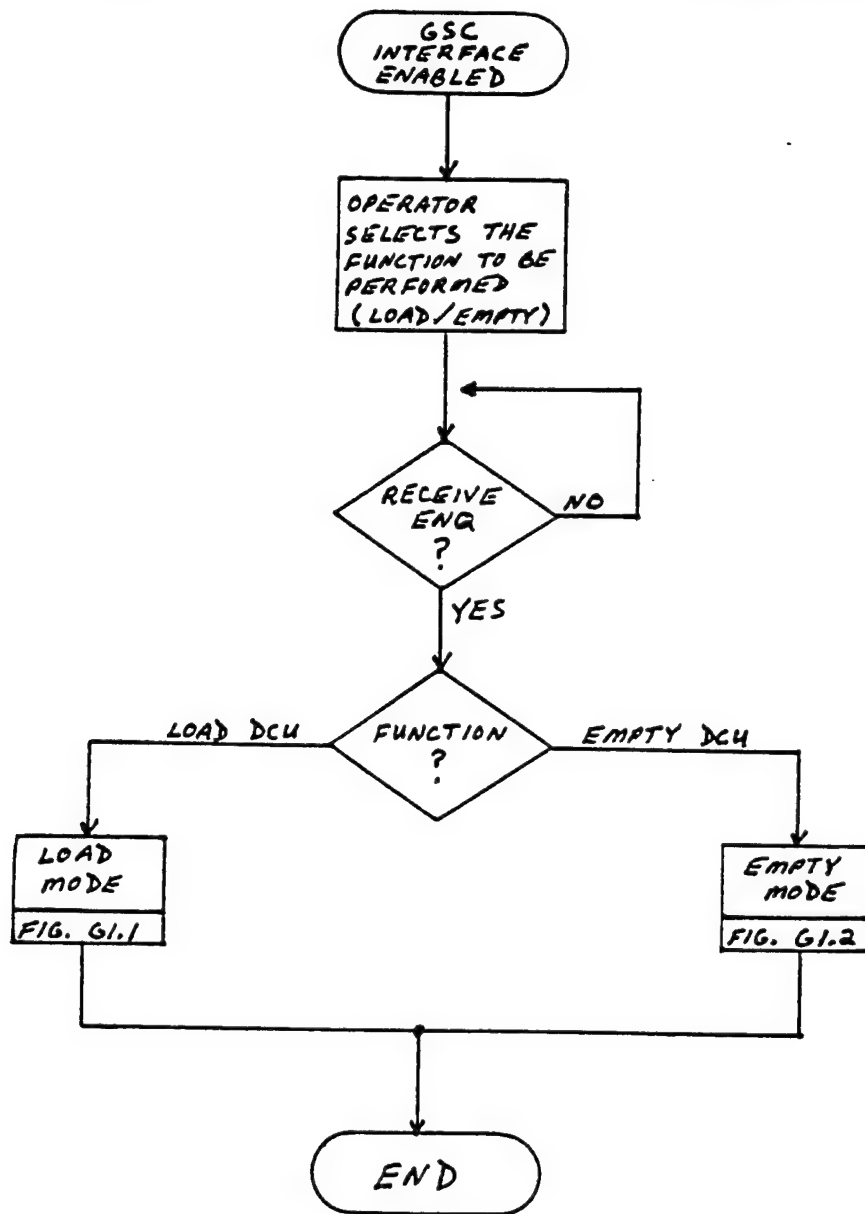


FIGURE G1.0, "GSC TO DCU COMMUNICATIONS"

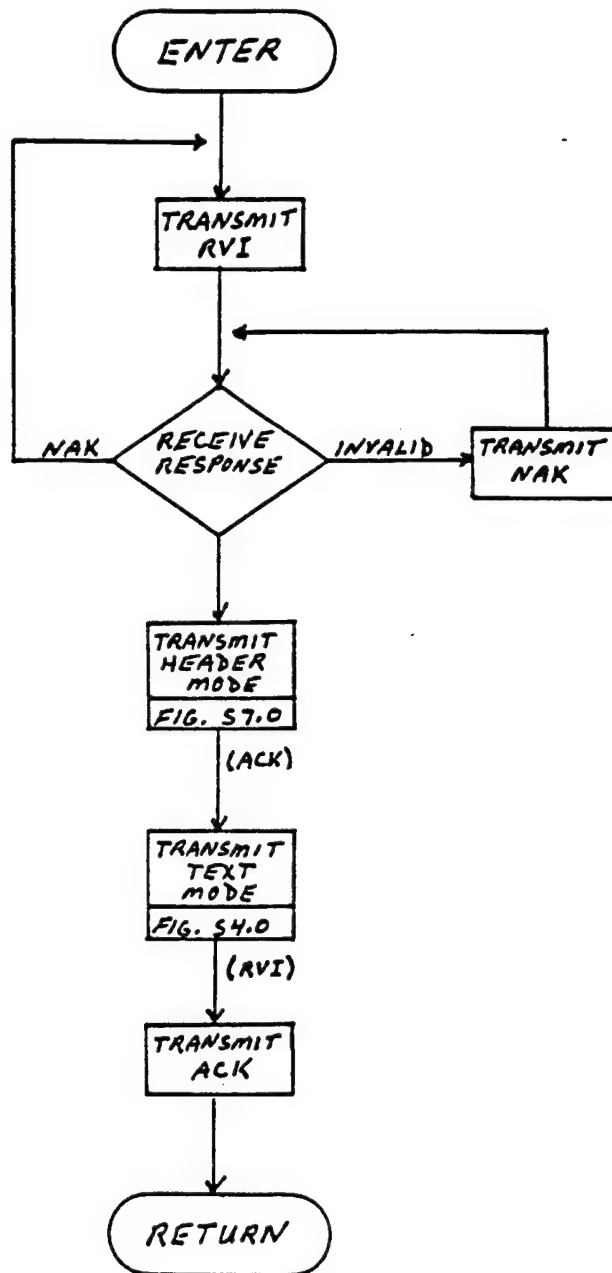


FIGURE 61.1, "GSC TO DCU LOAD MODE"

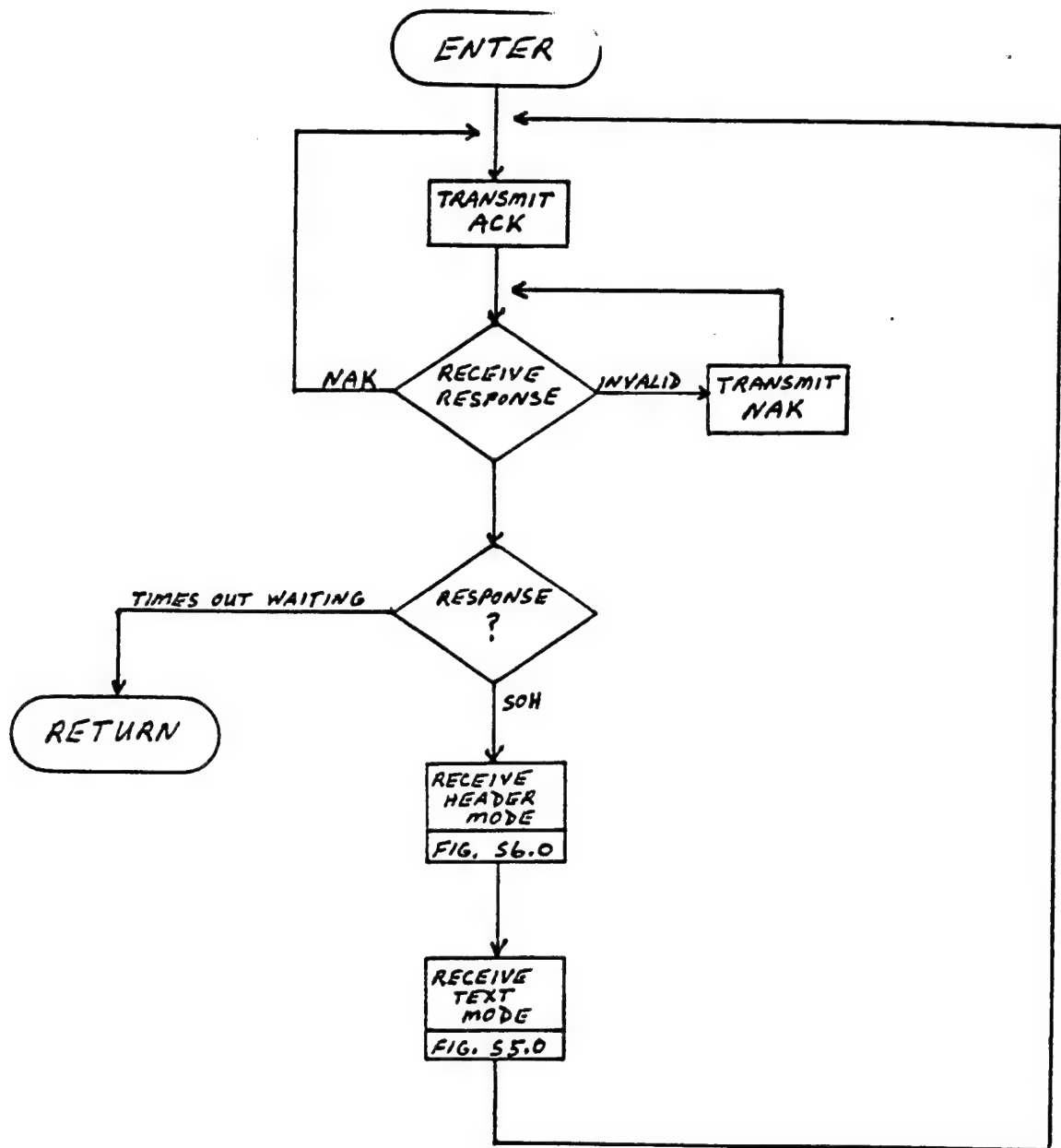


FIGURE G1.2, "GSC TO DLU EMPTY MODE"

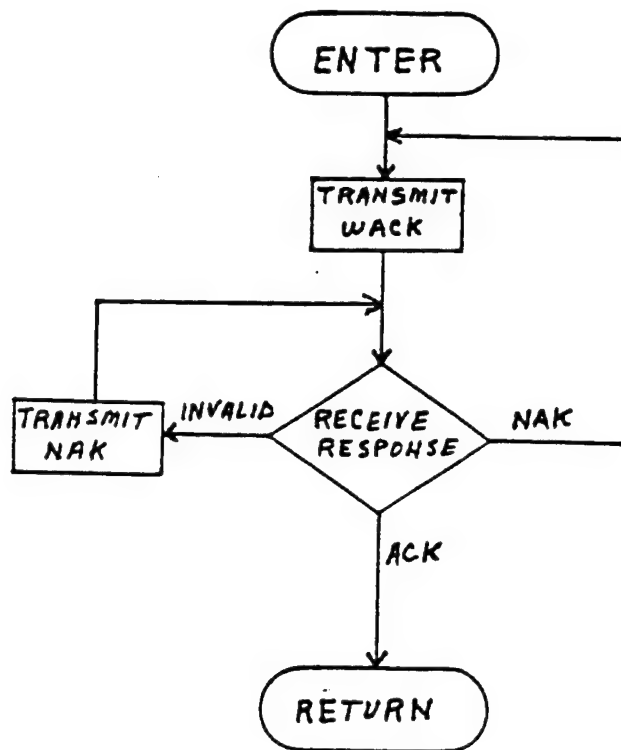


FIGURE S1.0, "WAIT STATE HANDSHAKE"

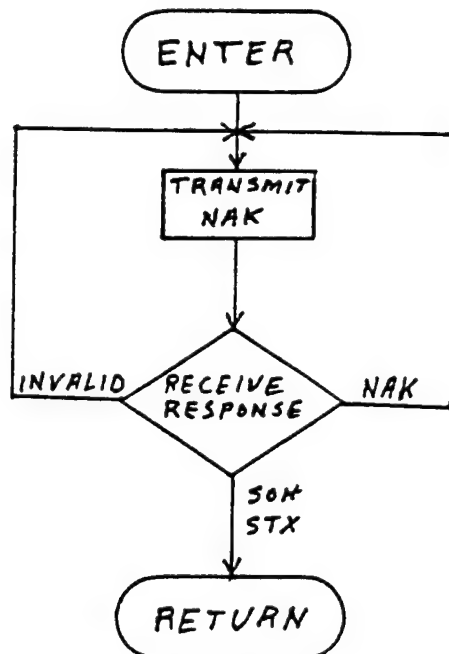


FIGURE S2.0, "RETRANSMIT BLOCK HANDSHAKE"

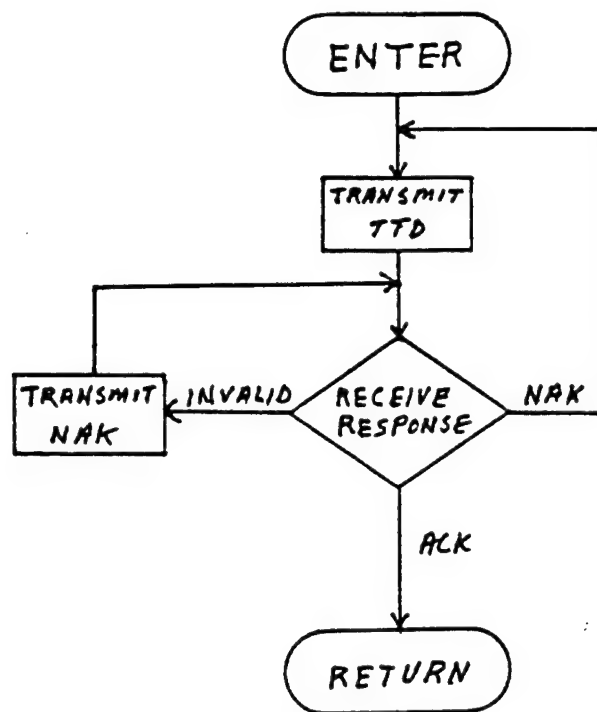


FIGURE 53.0, "HOLD LINE HANDSHAKE"

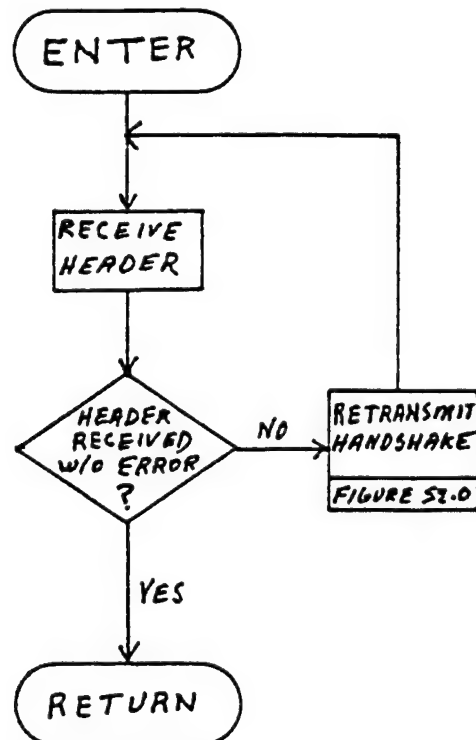


FIGURE 56.0, "RECEIVE HEADER MODE"

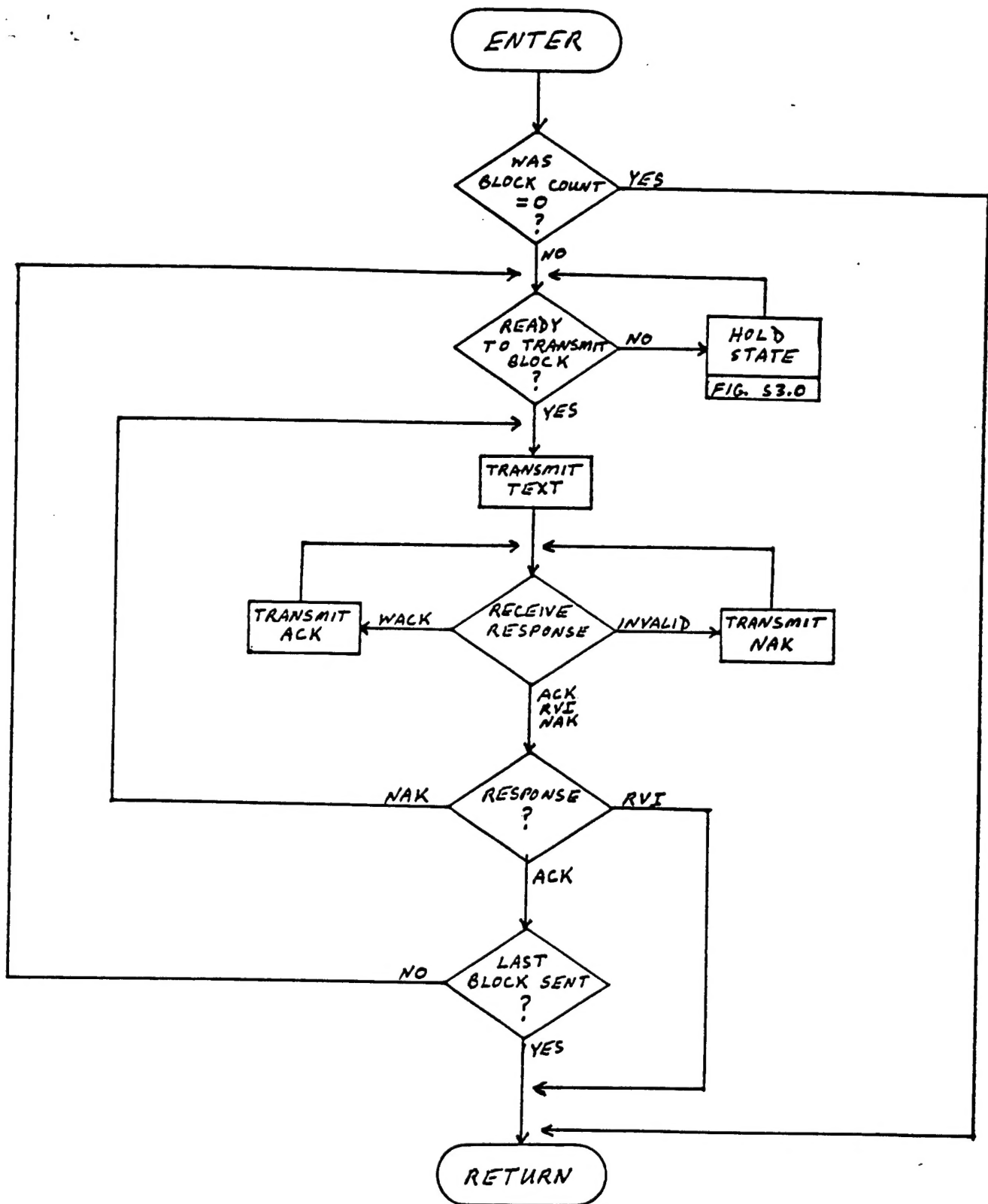


FIGURE 54.0, "TRANSMIT TEXT MODE"

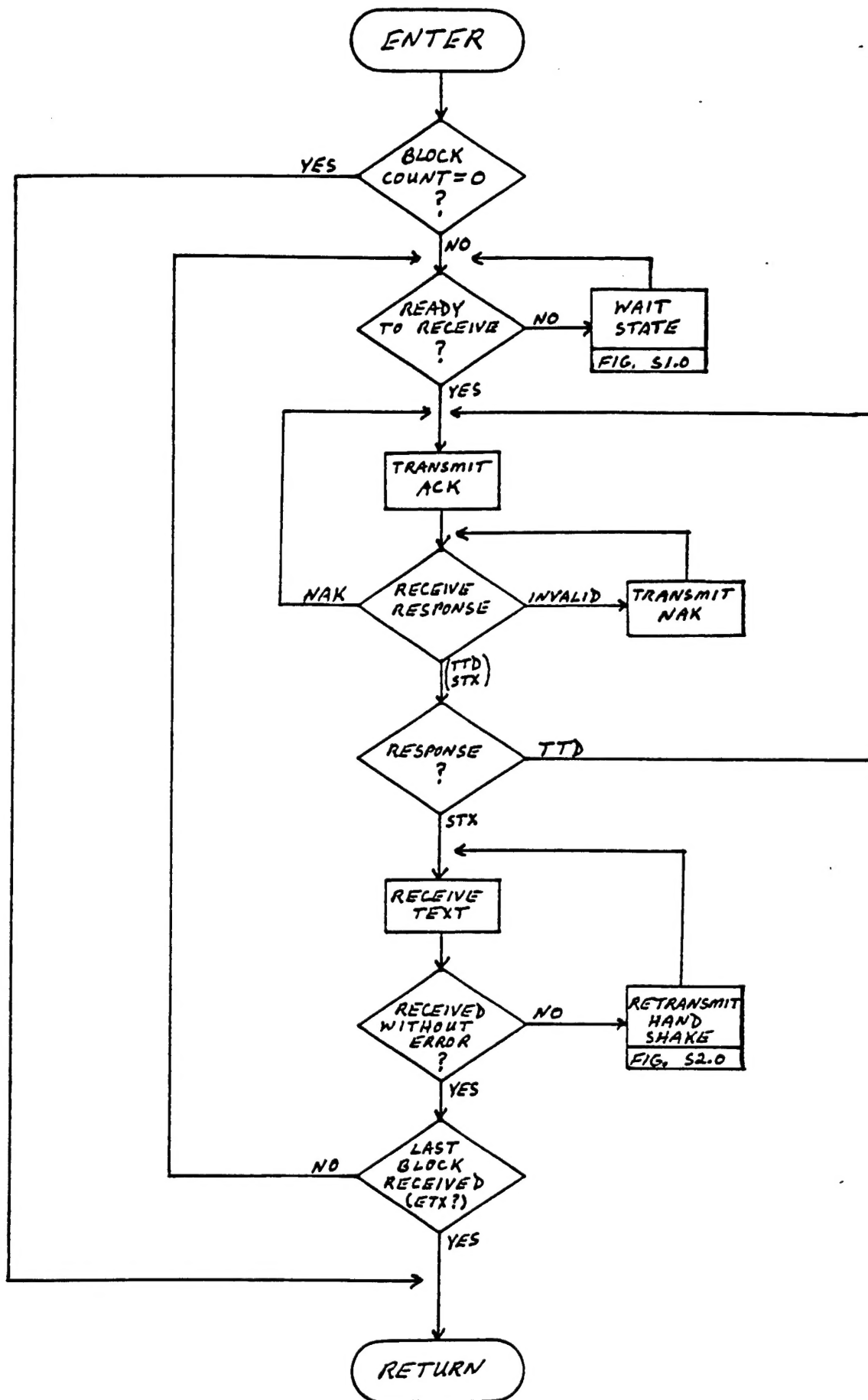


FIGURE S5.0, "RECEIVE TEXT MODE"

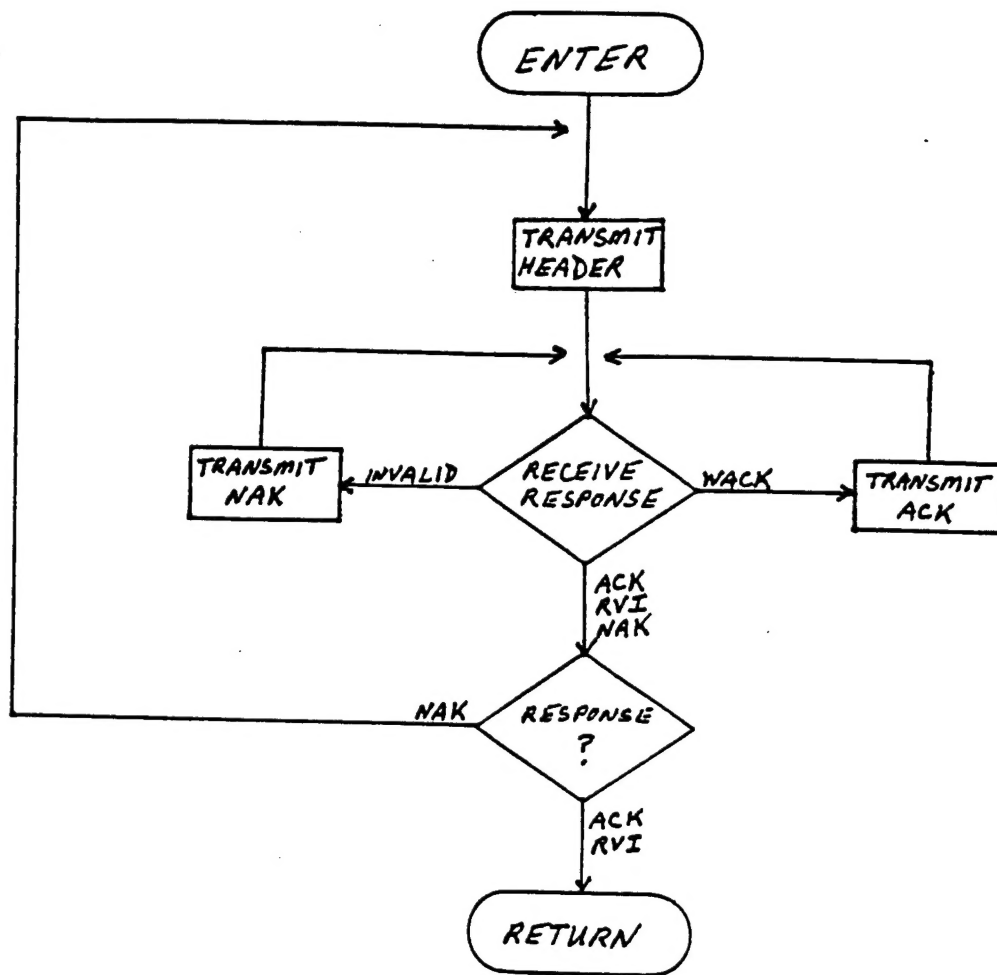


FIGURE S7.0, "TRANSMIT HEADER MODE"

NOTES

- (1) DEVICE MUST BE CAPABLE OF DISTINGUISHING BETWEEN AN INVALID CONTROL CHARACTER (CC) AND INVALID START OF BLOCK TO KNOW WHEN TO "NAK".
- (2) THE DCU TRANSMITS "ENQ" PER PARAGRAPH 3.2.3.8 UNTIL A VALID RESPONSE IS RECEIVED.
- (3) SAME AS (2)
- (4) THE HEADER LOADED INTO THE DCU FROM THE GSC SHALL CONTAIN AN ASCII ENCODED "!" PER PARAGRAPH 3.2.2.1.7